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NOTES ON TWO FREE-LIVING LARVAL TREMATODES FROM NORTH AMERICA *

Henry B. Ward

The life history of parasitic worms has always been a subject of especial interest and no part of it commands more careful attention than that which deals with the brief stages of free existence, for here is the point at which the organism effects its transfer from one host to another. It is only in the few highly specialized types that the parasitic habit endures in unbroken succession from host to host and the parasite is transferred by the agency of the organism in which it is living. This is the case with the *Plasmodium malariae* and all other parasites transferred by a blood sucking host to a new environment in which usually if not always a new generation is developed. It is also the case with the trichina and other encysted parasites which are acquired by a new host thru its carnivorous habit and which develop into a new form or stage of the life history in this new host rather than as a new generation.

In the simpler cases, however, the parasite abandons at intervals the parasitic mode of life and adopts a free-living habit for a stage of its existence or for a generation that alternates with the parasitic type. The free-living generation or stage is of especial interest because it affords the opportunity for the infection of a new host and also furnishes a point of attack in the life cycle which is vulnerable so that the readjustment of environmental conditions may block the transfer and prevent the infection. Such a readjustment may result from the natural operation of external forces, as when a very dry season eliminates the small ponds or swamps in which the free stage develops and thru which it secures means of transfer to the new host. Or the change may be brought about by the introduction of hygienic regulations that are drafted to prevent the parasite from reaching its new host, as the installation of a new sewage system may divert the human feces with tapeworm eggs from the lake into which they were formerly discharged and thus prevent infection of the fish host in that lake with the bladder stage of the fish tapeworm (*Dibothriocephalus latus*); consequently the spread of the tapeworm in the human host is checked.

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Attention has been forcibly directed in the past year to the free-living stages of trematodes by the work of Japanese and European investigators on the life history of the Lungfluke (Paragonimus) and the Bloodfluke (Schistosoma). As a result of these studies it is possible now for the first time to draw a reasonable picture in outline of the development of these forms. Almost nothing has been ascertained concerning the free-living stages of such parasites in North America. A few observations were made years ago by Leidy and recently Cort has published a careful study of some larval trematodes; but together these cover only a few of the many North American species of fluke. The importance of placing on record all data leads me to print here observations made some years ago although they are yet unfortunately incomplete. For the satisfactory interpretation of these observations a preliminary statement may be made here regarding the process of development as found in the trematode.

Two free-living stages recur in the development of most flukes. From the egg develops a small ciliated larva, designated a miracidium by Braun, which is evidently dependent upon water for its distribution. It remains within the shell until it has reached its full development; thereafter contact with the water is sufficient to open the shell and bring about the escape of the embryo. Active migration through the water permits it to reach and infect the secondary host, a mollusk. It is a somewhat striking fact that in spite of the constant and abundant production of eggs and embryos, no records that I have found note the occurrence of such embryos in plankton or other fresh-water collections. The absence of records can not be attributed to the small size of the miracidia since other even more minute objects fall constantly within the ken of the microscopist engaged in the study of fresh-water organisms, and some that are apparently very difficult to detect have been studied and described in detail. It may be due to the extreme delicacy of the larvae which are thereby readily subject to accidental destruction. Certainly they go to pieces almost as soon as they are collected.

The second free-living stage in the life history of the trematode comes when the cycle of development within the mollusk is completed and the transfer to the adult host takes place. This transfer occurs in the cercaria stage and of course may be direct if the mollusk is eaten by a suitable host. Yet one may safely infer that this is not the usual method since most cercariae are so well adapted to a free aquatic existence. The ordinary cercaria possesses a well developed swimming organ in the tail which characterizes this stage and is cast off when the larva reaches a new host or a place of encystment, as the case may be.

This swimming tail is reduced in a few types and absent only very infrequently.

In other cases the tail is not only present but powerful and displays various modifications, such as bristles, folds, branches, lateral membranes, etc., that increase its functional value. No one who watches living cercariae in the laboratory under experimental conditions can doubt that they are robust swimmers and naturally depend on that method for their transfer from the mollusk to the final host. When infected snails are kept in an aquarium jar on the laboratory table, the cercariae swarm out voluntarily at certain times in great numbers and in many cases can be seen with the unaided eye swimming actively about in the water. They do not confine themselves to the sides or bottom of the vessel but seem to seek equally the open water and in general to conduct themselves under such circumstances like other plankton organisms: protozoa, rotifers, and entomostraca in the same aquarium.

These cercariae are large objects among the microscopic aquatic organisms; they are produced in great abundance and infected mollusks are also abundant and widely distributed. And yet there are almost no records of the occurrence of cercariae in the voluminous reports on fresh water plankton and aquatic life. I am at a loss myself to explain this condition. I have seen them many times in fresh water collections, but only when the material was examined very soon after it was taken in the net. Usually the number of specimens secured was too limited to permit of satisfactorily determining the structure and relationships of the form. In two cases, however, the cercaria was so peculiar as to justify this record of its occurrence even though the description is incomplete in certain respects.

CERCARIA ANCHOROIDES *nov. spec.*

The first species to which attention is called was abundant at Lake St. Clair in 1893 and was described very briefly in a preliminary report (Ward, 1894), as follows:

In the tow was found but one helminth, a form which challenged attention the first of our stay. It is a free-swimming Cercaria, closely allied to *C. mirabilis* Braun, having a prominent tail terminating in two flat blades at right angles to the main body. The distome is enclosed within the tail of the Cercaria which has then more or less the appearance of an anchor with wide flukes. From one to four of these were taken from both top and bottom tow every day from July 27 to August 5 when it suddenly ceased to be found. Efforts to find the intermediate and primary host were alike unsuccessful. This form differs considerably in size from those described by R. R. Wright and M. Braun and is probably a new species.

The cercaria attracted attention by its very active movements, which were so peculiar that it could be readily picked out from other material in a glass dish. While found in collections from the surface as well as in those taken by a runner net and representing thus the fauna near the bottom, yet it was three times as frequent in the latter as in the former. This probably indicates that the cercariae were discharged from snails or other mollusks living on the bottom in the region where the collections were made.

Viewed under a lens the organism appeared as a minute object shaped like a hammer or anchor and swam through the water by a succession of violent jerks. The body moved with the flukes of the anchor in advance and propelled itself by throwing the flukes alternately right and left. In this movement the flexure occurred in the stem of the anchor about one third of the distance from the flukes to the head, and the blades did not move separately but maintained constantly the same relation to each other and to the adjacent part of the stem. The motion recalled distinctly the sweep of a double headed paddle as it is passed from the one side of a canoe to the other.

A more careful examination showed that the stem of the anchor was flat and also the flukes which extended from it nearly at right angles but were curved a little near the outer end. The head of the anchor appeared, however, nearly round, being enlarged and enclosing a small object which lay in a clear, fluid-filled chamber at the extreme head end of the stem (Fig. 2).

The stem of the anchor measured about 2 mm. in length and the flukes were each 0.53 to 0.6 mm. long, though on account of the curve their tips were only 0.84 mm. apart. The flukes varied in width from 0.24 to 0.34 mm. and the stem was 0.28 mm. in maximum width but was reduced to 0.2 mm. at the region of transition from the flat base to the rounded head. At its widest part near the outer end this region had increased again to about 0.3 mm. in diameter.

Under the microscope one could readily distinguish that the object in the enlarged end was a small distome. It lay with the oral sucker near the apex of the chamber and with the opposite end turned towards the flukes of the anchor. In no case was it coiled, twisted, or crumpled together in life but lay flat and straight with abundant space in the chamber for it to be extended to full length. When the distome lay flat on the slide, the base of the stem and the flukes of the anchor stood on edge, thus the breadth of the distome was at right angles to the flat surface of the stem and flukes.

The living distome was faint sulphur yellow with a reddish brown intestine; the anchor stem and flukes were dark by transmitted light and white or faint yellow by reflected light.

Under the pressure of the compressor the young distome (Fig. 1) was forced out of the sac in which it was contained. It emerged at the extreme tip where there seemed to be a preformed opening and left wrinkled and collapsed a thin walled sac in which it had been enclosed. The base of the stem and the flukes of the anchor remained entirely unchanged and often moved about actively in the water for some time after the distome had escaped, beating alternately right and left in the same manner as before and moving freely through the open water just like those specimens in which the distome was still enclosed in the sac.

The young distome, freed from the sac in the tail, as the anchor should properly be called, measured in life 0.64 mm. in length by 0.288 mm. in breadth. The oral sucker was sub-terminal or ventral, being separated 0.016 mm. from the extreme anterior tip; its diameter was 0.16 mm. and its orifice measured 0.048 × 0.064 mm. The ventral sucker though conspicuous was a little smaller than the oral, measuring 0.128 by 0.144 mm. and being separated from the anterior tip by a distance of 0.27 mm.; its orifice measured 0.04 by 0.072 mm. The pharynx was 0.064 mm. in diameter, and in some cases even a little longer.

The intestine was large, broad, wavy in outline, and filled with a dark reddish brown fluid containing numerous highly refractive granules. The main duct of the excretory system extended from the posterior tip to the acetabulum and two longitudinal trunks were conspicuous on the right and left sides of the worm, outside the intestinal crura. They were not straight but much twisted or thrown into short heavy wavy loops from which fine branches extended towards the margin and gave rise to still finer branches. In one specimen a transverse connection was demonstrated just anterior to the acetabulum extending from the median posterior trunk to the left longitudinal trunk. It was also noticed that the right canal in the same worm was certainly larger near the center of the body than near either end. This condition would indicate that a connection existed at the center in this tube also. One would not go far astray in interpreting the median posterior stem as the bladder from the apex of which near the acetabulum branches extended right and left to divide again near the margin on each side of the body into anterior and posterior trunks.

On the ventral surface of the body appeared a transverse slit just 15μ in front of the anterior margin of the acetabulum in the living specimen, or halfway between it and the oral sucker in a contracted alcoholic specimen. While the ducts connected with it were not yet developed or at least demonstrable there seems little doubt that this represents the genital pore. In the center of the body behind the acetabulum and between the intestinal crura three faint masses were discernible. The two smaller bodies near each other slightly oblique to the axis and furthest posteriad, are probably the testes and a single larger mass between the testes and the acetabulum is no doubt the ovary. These structures were faint, especially the ovary, and the connecting ducts of the genital system were not yet apparent. The three bodies differ slightly in size and location in different specimens.

The sac at the head of the anchor stem had on the outer surface peculiar vacuolated wart-like protuberances. These may have been sensory structures. In the outer wall were also two sets of fibers—probably muscular—of which those in the transverse series are closer together and very regular whereas the longitudinal fibers are neither so abundant nor so regular. The wall of the sac adjacent to the cavity consists of a thin epithelial layer.

In 1885 R. Ramsey Wright found a single specimen of a similar form swimming actively in a fresh water aquarium at Toronto. He published a brief note (Wright, 1885) in which the form was interpreted as a free-swimming sporocyst. Leuckart to whom the specimen was sent with notes and a sketch published (1886) a more extended description with a copy of Wright's drawing. From this account it is easy to determine that the form is very similar to that described above but not identical with it. Both the length which is "nearly 1 mm." (Leuckart) as against 2 mm. in the new species and the form of the tail as well as of the young distome indicate the specific difference of the two types. As appeared later both Wright and Leuckart were in error in the interpretation of this organism which is not in any sense a sporocyst but a true cercaria although with an unusual type of tail. No name has ever been given to this species, which may be designated *Cercaria wrightii* nov. spec. According to the sketch published by Leuckart (1886:102) the distome fills three fifths of the stem of the anchor, the flukes are nearly straight and together two thirds as long as the stem, and the genital organs of the distome form a solid rod-like mass located above the acetabulum but partly preacetabular and partly postacetabular. The approximate measurements of this form taken from the drawing are, total length 0.75, maximum width 0.133, length of flukes 0.533, breadth of flukes 0.1, length of distome 0.45, breadth of distome 0.1, diameter of oral sucker 0.041, of ventral sucker 0.075 mm. Leuckart speaks of the movement of this species as produced by flapping the two wing-like flat fins, evidently depending on the notes of Wright, though the latter in his printed notes did not refer to the way which the animal moved.

Later M. Braun (1891) published an extended account of a similar form which he also found swimming in an aquarium. The material came from Kurland. He was able to show that the form was not a sporocyst but a true cercaria in which the tail was developed to form a receptacle at the anterior end for the body of the young distome. He traced the larva back to *Limnaea palustris,* var. *corvus* and found in the lungs of these snails the numerous sporocysts from which the cercariae had come and in which could still be seen all stages in their development. He named this form *Cercaria mirabilis,* and decided that it was certainly different from Wright's species. From his description which agrees in general with Wright's type and with my own, some items may be cited to indicate the differences between the three.

Cercaria mirabilis Braun is 6 mm. long with leaflike, movable wings, 1.5 mm. long. In resting it lies on the bottom with folded wings. In swimming the wings are moved actively from side to side, making the motion resemble that of mosquito larvae. The young distome was an opaque yellow body, lying bent in a space lined by a smooth membrane. Granules of yellow pigment occur abundantly forming a network of lines in the bulb wings, and stalk, and also massed in the intestinal crura. The acetabulum is larger than the oral sucker. The rudiments of two testes and the ovary lie behind the acetabulum.

Since the early stages in the development of *Cercaria mirabilis,* taken from sporocysts, are split-tailed cercariae, Braun regarded this form as the higher differentiation of that type. He compared it with a number of known species but found nothing that furnished a real parallel. He was also unable to suggest to what adult distome this larval form should be assigned.

One further point deserves additional emphasis, namely that the method of swimming adopted by all three of these forms differs widely from that of a typical cercaria. While there are minor differences in movement as already noted, yet all accounts agree in stating that the forms travel with the wings in advance, trailing behind them the stem at the end of which lies the distome in the chamber. The distome is so oriented in these cercariae that the anterior end hangs down or back and the posterior end is pointed in the direction in which the larva is moving. It will be clear on comparing this with the usual cercaria that the orientation is precisely reversed; instead of being pushed ahead by the tail the distome in this case is pulled along after the tail. This is an extremely interesting case of the reversal of functional activity.

CERCARIA GORGONOCEPHALA *nov. spec.*

The other cercaria came from Lake Erie near Put-in-Bay, Ohio. It was taken in a tow from a depth of 4 fathoms on July 23, 1901. Unfortunately only a single specimen was obtained. Under a dissecting microscope the object resembled a writhing mass of serpents tied together by the tails. The diagrammatic representation (Fig. 3) gives, unfortunately, little idea of the actual appearance this object presented in life. The bunch contained not less than 50 separate stalks fastened firmly together at the base, all in active motion with a spiral twist passing in wave-like progression from the base to the outer end of the stalk (Fig. 5). The base of each stalk carried a bulbous expansion which in some stages of contraction appeared to be sharply cut off from the rest of the stalk but at other times graded into the stalk without any distinct boundary. This basal enlargement was thicker walled than the stalk elsewhere and possessed yellow pigment granules that were not found in other parts. The stalk was very mobile, delicate in texture and provided with two irregular longitudinal stripes of granular brown pigment which terminated just short of the outer tip. This stalk which is the region of marked contractile activity, tapered slightly (Fig. 4) to the extreme outer tip where it bore the body of a young trematode that appeared to be an amphistome. About half of the stalks had already lost their attachments; most of these still twisted and vibrated nearly as actively as those that carried the young helminths; but a few were pale in color, appeared empty like dead algal filaments, and were motionless. At times all the stalks rested quietly for a brief period and then suddenly began to be violently agitated together. During this movement it was clear that the stalk alone was active whereas the worm was snapped too and fro like the lash of a whip.

As the stalk vibrated with a coiling or twisting motion, the worm at the end was turned at every angle and it seemed as if the large posterior sucker was mounted on a stalk or at least protruded distinctly beyond the general surface of the body. The general form of the amphistome was oval with a concave ventral surface and the anterior end rolled slightly ventrad (Fig. 6) so that the oral sucker was partly concealed. The body of the worm was white, opaque and almost entirely immobile. No internal organs could be detected either in the attached worms or in those that had been shaken off and lay free in the dish. The posterior end of the detached amphistome bore a distinct projection which indicated the point at which the stalk had been attached.

A somewhat similar form was discovered by Claus in the Mediterranean in 1880 and recorded by Leuckart (1886: 87). It is referred to in various other places as a Rattenkönigcercaria. It was carefully described by Pintner (1891) under the name of *Cercaria clausii* given it by Monticelli in 1888. Odhner has more recently (1911) shown this to be the larval form of *Phyllodistomum acceptum* Looss. Apart from the peculiar habit that both forms are borne on stalks tied in bunches there is no close similarity between *Cercaria clausii* and *C. gorgonocephala.* The details of structure in the stalk are as unlike as the structure of the two worms.

It is not without some reserve that the species described above is assigned to the amphistomes. The form of the body suggests this connection but the amphistome cercariae thus far known are very different in type. Cort (1915) has described two species from this group very fully and in common with earlier investigators he finds that two eye spots are present in these cercariae. No eye spots were observed in *Cercaria gorgonocephala.* It is possible that the large sucker of this cercaria is in reality not posterior but ventral and that the postacetabular region is yet undeveloped. No definite opinion on the relationships of this form can be given until further material is obtained.

In one minor structural feature this species manifests a striking resemblance to another amphistome cercaria described by Cort. It is clear that the stalk is the homolog of the cercaria tail and as can be readily seen from an inspection of the sketches published herewith this stalk is attached to the young trematode not at the extreme posterior tip so as to form a direct posterior extension of the body, but rather to the dorsal surface just anterior to the end of the body so that the longitudinal axis of the worm when extended lies ventral to that of the stalk. This same relation mentioned by Cort in his text is beautifully illustrated in his sketch of *Cercaria diastropha* (Pl. 3, Fig. 24). The condition exists also in other amphistome cercariae.

One other point deserves especial notice here. While the stalk in this species is in one way an organ of attachment rather than a swimming organ, yet it retains its muscular development and structure relatively unchanged, and in movement vibrates in a manner which suggests to the eye the close similarity to the moving tail of an isolated swimming cercaria. One can then not find a basis for calling this in a real sense a change of function in the organ. The young distome in *Cercaria gorgonocephala* (Fig. 6) is broader and flatter than any yet described in the group of Amphistomata. North American adult amphistomes are only very imperfectly known and I am unwilling at present to venture a conjecture as to the form to which this cercaria belongs.

The two cercariae discussed in this paper manifest an interesting biological similarity. Both differ from the ordinary cercaria in the peculiar development of the tail, which has become so highly specialized that its original character is not easily discerned. In one case it has become a very efficient organ of locomotion, conspicuous both for its size and its power; in the other case it has given up its swimming function though not its power, and serves to attach the larval worm to others in the group. In both cases the end result is the same: The larva swimming about in the open water forms a most conspicuous object and is readily snapped up by fishes as Braun determined experimentally with *Cercaria mirabilis*. The conspicuous character of both larvae was also shown in their prompt discovery in the tow although they were surrounded by large numbers of other plankton organisms. Their activity and conspicuousness must be helpful in enabling them to reach a suitable host for further development, and such a host will naturally be sought among the fishes of the waters in which the larvae occur.

SUMMARY

A description is given of the structure and activity of two new cercariae of peculiar type captured free in Lake Erie and Lake St. Clair. They are designated *Cercaria anchoroides* nov. spec. and *C. gorgonocephala* nov. spec., and are compared with known European species. Altho such an occurrence must be common, these forms are the first to be taken in open fresh waters.

REFERENCES CITED

Braun, M. 1891. Die sogenannte "freischwimmende Sporocyste." Centr. Bakt. Par., 10:215-219.

Cort, W. W. 1915. Some North American Larval Trematodes. Ill. Biol. Monogr., 1:447-532, 8 pl.

Leuckart, R. 1886. Die Parasiten des Menschen. Leipzig, Bd. 1, Abt. 2, Lief. 1.

Monticelli, F. S. 1888. Saggio di una morfologia dei Trematodi. Napoli, 130 pp.

Odhner, Th. 1911. Zum natürlichen System der digenen Trematoden IV. Die Familie Azygiidae n. fam. Zool. Anz., 38:513-531, 2 figs.

Pintner, Th. 1891. Ueber Cercaria Clausii Monticelli. Arb. Zool. Inst. Wien., 9:285-294, 1 pl.

Ward, H. B. 1894. A Preliminary Report on the Worms (mostly parasitic) Collected in Lake St. Clair, in the Summer of 1893. Bull. Mich. Fish Com., 4:49-54, 1 table.

Wright, R. R. 1885. A Free-Swimming Sporocyst. Amer. Nat., 19:310-311.

EXPLANATION OF PLATE

Figs. 1 and 2.—*Cercaria anchoroides.* 1, young distome just set free, × 37; 2, *Cercaria* complete, × 105.

Figs. 3 to 6.—*Cercaria gorgonocephala.* Free hand sketches from life. For details see text.

PLATE